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Beyond air pollution: a national assessment of cooking-related burns in Ghana

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► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/ip-2023-045191).

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Received 30 November 2023
Accepted 18 July 2024

ABSTRACT

Introduction Household energy transitions have the potential to reduce the burden of several health outcomes but have narrowly focused on those mediated by reduced exposure to air pollution, despite concerns about the burden of injury outcomes. Here, we aimed to describe the country-level incidence of severe cooking-related burns in Ghana and identify household-level risk factors for adults and children.

Methods We conducted a national household energy use survey including 7389 households across 370 enumeration areas in Ghana in 2020. In each household, a pretested version of the Clean Cooking Alliance Burns Surveillance Module was administered to the primary cook. We computed incidence rates of severe cooking-related burns and conducted bivariate logistic regression to identify potential risk factors.

Results We documented 129 severe cooking-related burns that had occurred in the previous year. The incidence rate (95% CI) of cooking-related burns among working-age females was 17 (13 to 21) per 1000 person-years or 8.5 times higher than that of working-age males. Among adults, the odds of experiencing a cooking-related burn were 2.29 (95% CI 1.02 to 5.14) and 2.40 (95% CI 1.04 to 5.55) times higher among primary wood and charcoal users respectively compared with primary liquified petroleum gas users. No child burns were documented in households where liquified petroleum gas was primarily used.

Conclusion Using a nationally representative sample, we found that solid fuel use doubled the odds of cooking-related burns compared with liquified petroleum gas. Ghana's efforts to expand access to liquified petroleum gas should focus on safe use.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Clean household energy transitions can substantially reduce air pollution exposure but their role in reducing morbidity that is not mediated by air pollution exposure is unclear.
⇒ Burns are a major public health problem that disproportionately burdens populations in low-income and middle-income countries (LMICs). Burns epidemiology in LMICs is hindered by a paucity of data.

WHAT THIS STUDY ADDS

⇒ We conducted the first nationally representative assessment of severe cooking-related burns in Ghana and evaluated their association with household-level risk factors including cooking fuel type.
⇒ We estimated an annual incidence of greater than 300 000 severe cooking-related burns in Ghana. Among adults, the odds of experiencing a cooking-related burn were 2.29 (95% CI 1.02 to 5.14) and 2.40 (95% CI 1.04 to 5.55) times higher among primary wood and charcoal users, respectively, compared with primary liquified petroleum gas (LPG) users. No child burns were documented in households where LPG was primarily used.
⇒ Importantly, household-level risk factors differed for adults compared with children.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The results of this study, if weighed against the LPG explosion risk associated with LPG delivery and unsafe use, may inform the Government of Ghana's plan to provide LPG access to 50% of the population.
⇒ The results also demonstrate that national burn registries accounting both for burns identified at the community level and through hospitals are needed to inform prevention strategies in LMICs where they are most needed.

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To cite: Daouda M, Seyram K, Amankwah GO, *et al*. *Inj Prev* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/ip-2023-045191

INTRODUCTION

Burns, which are preventable, are a major public health problem.[1 2] Burns are among the most devastating of all injuries—often resulting in significant morbidity and requiring long-term treatment[2]—and rank as the fourth most common type of trauma worldwide.[3] Annually, burns result in more than 7.1 million injuries, the loss of almost 18 million disability-adjusted life-years and more than 250 000 deaths worldwide.[4] Every day, over 30 000 people worldwide suffer new burns, severe enough to warrant medical attention, equating to an estimated 11 million new burns each year globally.[5]

The risk of burns is unequally distributed both between and within countries. The burden of burns is borne disproportionately by people residing in low-income and middle-income countries (LMICs) with over 90% of all burns worldwide occurring in LMICs.[1 2 4] In particular, over two-thirds of all burns occur in African and South-East Asian

regions.[1 5] Further, among hospitals from the WHO African Region reporting data to the Global Burn Registry, the average duration of stay for burn patients is longer than the global average.[6] At the individual level, children and adult women are particularly vulnerable to burns.[1] Children under the age of 15 in LMICs are more often burnt than children in high-income countries (HICs), usually as a result of exposure to flames or scalding.[5] The incidence of burn deaths among children under 5 years of age in the WHO African Region is over twice that of children under 5 years of age worldwide.[1] For women, the age group most commonly burdened by burns is 16–35 years[7]; burns are one of the few injury mechanisms whose incidence and death toll are higher among women than men.[5]

Burn prevention strategies have been associated with a reduction in the incidence and severity of burns, length of hospital stay and mortality rate in HICs.[5] Such strategies, including educational programmes and environmental modifications (ie, smoke alarms, controlled hot water and fire-retardant fabrics), are generally lacking in LMICs.[8 9] Notably, well-designed intervention programmes in HICs have also demonstrated cost-effectiveness.[10] Given the disproportionate burden of burns in LMICs, burn prevention strategies should be a public health focus in these countries. However, a main barrier to development and implementation of such programmes is a paucity of data regarding the incidence, hazards and risk mitigating factors of burns.[8 9] A limited number of studies have documented burns occurrence in LMICs,[2] but those that have suggest that, most burns occur at home, especially in the kitchen. Further, the use of potentially unsafe cooking appliances and open fires at floor level are seen as major risk factors for flame-related burns.[7] The use of liquified petroleum gas (LPG) provides an alternative but is often perceived as risky because of the potential for explosions. This points to choices around cooking fuels as a significant modifiable risk factor in the prevention of burns in LMICs.

It is understood that household energy transitions, especially those designed to displace the use of solid fuels (ie, wood, charcoal, crop residue and animal dung), have the potential to improve health.[11] Incomplete combustion of solid fuels results in high levels of household air pollution, which is estimated to account for 2.3 million premature deaths annually.[12] Exposure to household air pollution is associated with numerous adverse health outcomes including pneumonia, lung cancer, and respiratory and cardiovascular mortality.[13] The majority of cooking interventions have thus focused on health outcomes mediated by reduction in exposure to air pollution.[13] The present study aims to expand the scope of potential health benefits worth considering in the context of household energy interventions. To do so, this study documents the prevalence of cooking-related burns in Ghana where a large-scale household energy transition is unfolding.

The Government of Ghana has committed to increasing access to LPG so that at least 50% of the population uses LPG as their primary cooking fuel.[14] To implement this policy, the country is transitioning from a refill model, in which households bring an empty cylinder to a filling station and choose how many litres to refill, to a recirculation model, in which households trade in empty cylinders for full ones. Currently, in Ghana (as in most of sub-Saharan Africa), more than 75% of the population relies on solid fuels to meet their cooking and heating needs.[15] The risk and occurrence of burns associated with these cooking practices in Ghana is unknown. Some studies have assessed potential risk factors for burns in the Ghanaian context and found that the majority of burns occurred at home and that most of them occurred in the kitchen.[16 17] While useful, these studies provide limited insight into the broader epidemiology and burden of burns in Ghana due to their restriction to specific populations (eg, children) or geographical regions.[16 17] Given the push towards increased LPG access and the safer infrastructural changes designed to promote uptake, characterising the cooking fuel-dependent incidence of burns in Ghana can help clarify the ramifications of household fuel transitions for burn risks.

To address this research gap, we leveraged data collection efforts as part of a nationally representative survey of household energy use in Ghana to document the incidence of severe cooking-related burns at the country level. We aimed to describe the incidence and burden of cooking-related burns among adults and children separately. Additionally, we aimed to identify household-level risk factors to inform the development of potential prevention strategies.

METHODS

Survey

The survey sample was constructed by Ghana Statistical Services to be nationally representative with regard to population distribution across the country. Power calculations were conducted to determine the minimum sample size, which was then adjusted for (1) the desired number of regional and urbanicity strata and (2) an assumed 80% response rate. The final sample included 7389 households across 370 enumeration areas (EAs) in all 16 regions of Ghana. Sampling details are presented in online supplemental table S1. Households were randomly selected at the EA level using random probability sampling.

Recruitment and data collection were conducted by trained and experienced enumerators led by 20 team supervisors. The survey was designed to be administered to the primary cook. If the primary cook was younger than 18 years old, was sick, had travelled or declined to be interviewed, team supervisors were notified, and another random sampling draw was performed to obtain a new respondent. Once identified, the primary cook provided informed consent. Only consenting respondents participated in the survey. Enumerators (all bilingual in English and Twi) were trained to administer the survey in Twi. Responses collected by the enumerators were entered into the Open Data Kit platform.[18]

Patient and public involvement

The design, topics and structure of the survey were developed through extensive piloting and engagement with community members. This process first occurred in Kintampo Health Research Center's operational areas (Kintampo and Ntankro), where a total of 70 households were interviewed. The questionnaire was additionally piloted in Gomoa Bewadze, Amenfie and Onyandze—all three communities are adjacent to Winneba, where training for survey officers was held. This involved 100 interviewers, 20 team supervisors and 5 facilitators, who piloted the questions with 200 respondents of diverse demographics including age, occupation, education and sex. Community members also provided feedback on word choice as well as the nature and relevance of illustrative examples (given varying local contexts) used to facilitate the comprehension of complex questions. Results of the study have been shared in various community meetings.

Burns module

The survey module on cooking-related burns was adapted from the Burns Surveillance Module,[19] a validated instrument developed and field tested by the Clean Cooking Alliance to facilitate

Table 1 Descriptive characteristics of study households (N=7389), Ghana

	No cooking-related burns in past 12 months (N=7275)	At least one cooking-related burn in past 12 months (N=114)	P value*
Urbanicity			0.623
N	7275	114	
Rural	3788 (52.1%)	62 (54.4%)	
Urban	3487 (47.9%)	52 (45.6%)	
Primary cooking stove			0.006
N	7162	114	
LPG	1441 (20.1%)	9 (7.9%)	
Wood	3484 (48.6%)	59 (51.8%)	
Charcoal	2212 (30.9%)	46 (40.4%)	
Other	25 (0.3%)	0 (0.0%)	
Cooking location			< 0.001
N	7089	110	
Inside	1792 (25.3%)	12 (10.9%)	
Outside	5297 (74.7%)	98 (89.1%)	
Urbanicity* cooking location			0.008
N	7089	110	
Rural, inside	787 (11.1%)	5 (4.5%)	
Urban, inside	1005 (14.2%)	7 (6.4%)	
Rural, outside	2907 (41.0%)	53 (48.2%)	
Urban, outside	2390 (33.7%)	45 (40.9%)	
Wealth index			0.006
N	7195	111	
Q1 (wealthiest)	1444 (20.1%)	17 (15.3%)	
Q2	1432 (19.9%)	29 (26.1%)	
Q3	1443 (20.1%)	18 (16.2%)	
Q4	1427 (19.8%)	34 (30.6%)	
Q5 (poorest)	1449 (20.1%)	13 (11.7%)	
Household size			< 0.001
N	7275	114	
Median	4	4	
IQR	2–6	3–7	
Primary cook age			0.193
N	7275	114	
Median	37	35	
IQR	28–49	26–46	
Primary cook sex			0.042
N	7275	114	
Male	823 (11.3%)	6 (5.3%)	
Female	6452 (88.7%)	108 (94.7%)	
Primary cook education			0.156
N	7274	114	
None	2238 (30.8%)	27 (23.7%)	
<SHS	3535 (48.6%)	65 (57.0%)	
Post SHS	1192 (16.4%)	20 (17.5%)	
Some university	309 (4.2%)	2 (1.8%)	
Household head age			0.574
N	7275	114	
Median	45	42.5	
IQR	35–57	35–58	
Household head sex			0.146
N	7268	114	
Male	4489 (61.8%)	78 (68.4%)	
Female	2779 (38.2%)	36 (31.6%)	
Household head education			0.043
N	7247	114	
None	2374 (32.8%)	25 (21.9%)	
<SHS	3113 (43.0%)	63 (55.3%)	
Post SHS	1312 (18.1%)	20 (17.5%)	
Some university	448 (6.2%)	6 (5.3%)	
Primary cook's relationship to household head			< 0.001
N	7274	114	
Self	3009 (41.4%)	33 (28.9%)	
Married to household head	3274 (45.0%)	58 (50.9%)	
Household head partner	119 (1.6%)	11 (9.6%)	
Household head daughter	526 (7.2%)	9 (7.9%)	
Household head son	64 (0.9%)	0 (0.0%)	
Other	280 (3.8%)	3 (2.6%)	

Respondents were interviewed between February and March 2021 and were asked about burns that occurred in the previous 12 months.
*ANOVA and χ^2 p values for continuous and categorical variables, respectively.
ANOVA, analysis of variance; LPG, liquified petroleum gas; Q1, first quintile; SHS, secondary high school.

the inclusion of a burns module in broader injury research as well as household energy surveys. Prior to deployment, the adapted survey was field tested as part of a pilot. The module was only administered to respondents who reported that at least one severe cooking-related burn occurred to a member of their household in the previous 12 months.

Severe cooking-related burns were defined as burns that occurred while cooking and were severe enough to need some kind of medical treatment or to change someone's 'normal' activity for one or more days. Examples of a change in normal activity include a person who, as a result of the burn, did not go to work or school or could not carry out household chores, or a baby who did not play/feed normally.

The respondent was asked to distinguish between burns that occurred to adults (18 years of age and above) and children (less than 18 years of age). If both an adult and a child experienced a severe cooking-related burn in the previous year, the module was administered to the respondent twice, once for each case. Given time and logistical constraints, as well as respondent fatigue, respondents were asked to describe severe cooking-related burns for one adult and one child only so as to constrain the duration of the interview. This survey design restriction implies that if two adults or two children experienced a severe cooking-related burns, the respondent was asked to identify the person who was most affected between the two.

Data on potential household-level risk factors, which were identified in the literature, were also collected as part of the survey. These variables included urbanicity (categorical), primary cooking fuel (categorical), cooking location (categorical), household size (continuous), household head age (continuous), household head sex (categorical), household head education (categorical) and wealth index (categorical). As previously described,[20] questionnaires assessed household characteristics

Table 2 Demographic characteristics of individuals who experienced cooking-related burns, Ghana

	Adult* (N=72)	Child (N=57)	P value†
Age			<0.001
Median	32	4	
Q1,Q3	23, 54	2, 7	
Sex			<0.001
N	72	48	
Male	7 (9.7%)	21 (43.8%)	
Female	65 (90.3%)	27 (56.2%)	
Relationship to respondent (primary cook)			<0.001
Other	4 (5.6%)	2 (3.5%)	
Spouse	6 (8.3%)	1 (1.8%)	
Son/daughter	9 (12.5%)	47 (82.5%)	
Daughter-in-law	0 (0.0%)	1 (1.8%)	
Grandchild	1 (1.4%)	5 (8.8%)	
Brother/sister	4 (5.6%)	1 (1.8%)	
Self	43 (59.7%)	0 (0.0%)	
Parent	5 (6.9%)	0 (0.0%)	

Respondents (N=7389) were interviewed between February and March 2021 and were asked about burns that occurred in the previous 12 months.
*Adults are individuals 18 and older; children are individuals younger than 18.
†ANOVA and χ^2 p values for continuous and categorical variables, respectively.
ANOVA, analysis of variance.

Table 3 Estimated overall and stratified incidence rates of cooking-related burns by gender and age group, Ghana

	Incidence rate (IR)*	95% CI	Estimated burden (Cases per year)†
Young‡			
Female	11	7.6 - 16	65 704
Male	8.4	5.3 - 13	51 414
Working age			
Female	17	13 - 21	162 539
Male	2	0.88 - 3.9	18 859
Older adults			
Female	9.1	3.8 - 19	5412
Male	1.5	0.14 - 7.1	752

Respondents (N=7389) were interviewed between February and March 2021 and were asked about burns that occurred in the previous 12 months. 95% CI = 95% confidence interval.
*Expressed as IR per 1000 person-years.
†Based on estimates of total population by age group from the World Bank.
‡Data on sex missing for 16% of the burn cases among young people.

that were enumerated as counts and used to generate a wealth index, a measure of relative household wealth.[21]

Data analysis

We described burns epidemiology and household risk factors separately for adults and children. Incidence rates and 95% CIs were computed with the Byar's approximation of the exact Poisson distribution to account for small numbers.[22] We then calculated the annual burden of burns (cases per year) stratified by sex for three age groups: young people (0–14), working-age people (15–64), older adults (65 and above). To do so, we multiplied the computed incidence rates by the population count in each age/sex group. The population counts were obtained from World Bank estimates[6] and can be found in online supplemental table S2.

We also conducted bivariate logistic regression to assess the relationship between risk factors and injury occurrence. For adults and children, respectively, the outcome was defined as the occurrence of at least one severe cooking-related burn. For children, the at-risk population was restricted to households that reported having children (at least one household member <18 years old). Firth penalised likelihood approach was employed to address the bias introduced by rare events as well as complete separation.[23] Firth's regression relies on a penalty term placed on the standard maximum likelihood function used in traditional logistic regression, which converges towards 0 as the sample size goes to an infinite number of observations.[23]

All analyses were conducted in R V.4.1.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

The survey sample was approximately evenly split between rural (52.1%) and urban (47.9%) households (table 1). Most household heads were male (61.9%) and were 46 years old on average. Out of 7389 respondents, 114 reported at least one severe cooking-related burn in the previous 12 months. Households that reported at least one burn tended to be slightly larger in size than households that did not report any burn (p<0.001). Nearly, all households (99.7%) used LPG, charcoal or wood as their primary fuel. The proportion of households that primarily used LPG was higher among those who did not report any burns (20.1%) compared with those who did (7.9%).

Across these 114 households, the large majority (90.4%) reported one severe cooking-related burn with a small fraction (2.6%) reporting three burns, which was the maximum number of burns documented in a given household in our sample (online supplemental table S3). The total number of burns reported, accounting for the fact that respondents could add up all the burns that took place in their household in the previous 12 months, was 129 (table 2). The median ages (IQR) of adults and children who experienced a burn were 32 (IQR: 23–54) and 4 (IQR 2–7) years, respectively. In both age groups, female individuals were more likely to have experienced a burn (p<0.001), but the proportion of adult females (90.3%) was much greater than that of female children (56.2%). Most adults who experienced a burn were the respondents themselves while most children were respondents' sons or daughters.

We used population size estimates by age group to assess the burden (number of cases per year) of severe cooking-related burns in Ghana. We estimated a much greater risk among young and working-age individuals compared with older adults (table 3). This burden disproportionately affects working-age females, whose incidence of severe cooking-related burns (17 per 1000 person-years) was 8.5 times higher than that of working-age males. In our sample, most burns occurred when biomass (charcoal or wood) was in use (figure 1). Notably, no child burns were documented when LPG was in use.

Factors that increased the risk of severe cooking-related burns differed between adults and children (table 4). Among adults, the odds (OR (95% CI)) of experiencing a severe cooking-related burn were twice as high for households whose primary cooking fuel was wood (2.29 (1.02 to 5.14)) or charcoal (2.40, (1.04 to 5.55)). Among children, the odds of experiencing such a burn increased (1.20 (95% CI 1.10 to 1.32)) with household size (for each additional household member) and decreased (0.30 (95% CI 0.14 to 0.67)) in households where the household head was female. In both groups, cooking outside increased the odds of

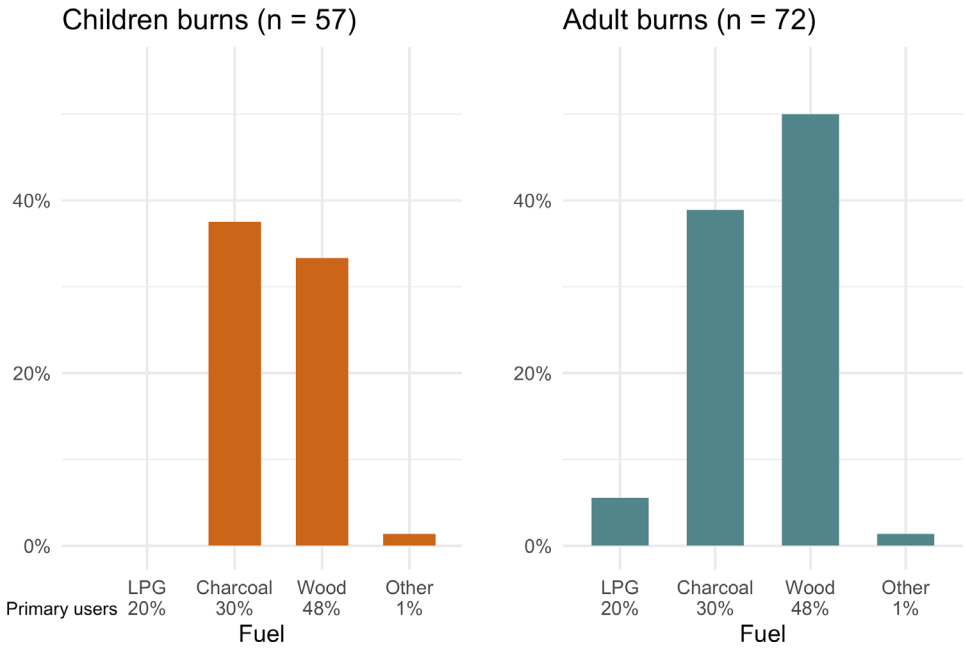

Figure 1 Cooking-related burns among adults and children by fuel type in use, Ghana. Respondents (N=7389) were interviewed between February and March 2021 and were asked about burns that occurred in the previous 12 months. The plot illustrates the percentage of documented burns in the study by fuel type in use at the time the burn occurred (brown bars). For reference and ease of interpretation, the plot also includes the percentage of primary fuel type users across all respondents. Results are stratified by demographic group (children vs adults). LPG, liquified petroleum gas.

burns. The relationship between living standard (as measured by wealth index) and the incidence of severe cooking-related burns was non-monotonic.

DISCUSSION

We conducted a national assessment of severe cooking-related burns in Ghana providing data at the country level for an injury outcome that is not currently routinely documented. We found that such burns were a rare occurrence but disproportionately affected working-age females. Among this group, we estimated an annual burden of approximately 160 000 cases. Regarding potential risk factors, no cooking-related burns were documented among children when LPG was in use. Conversely, the use of biomass (wood and charcoal) doubled the odds of experiencing severe cooking-related burns among adults.

We find that the use of LPG for cooking decreases the odds of severe cooking-related burns compared with biomass fuels. Our group has previously demonstrated that a randomised LPG intervention in communities that predominantly used wood fuel decreased exposure to carbon monoxide by 47% (95% CI 34% to 57%).[24] The present study suggests that the benefits of switching from biomass fuels to LPG extend beyond cardiorespiratory health to include a reduction in the risk of severe burns. This finding has positive implications for the Government of Ghana's current plan of expanding LPG access from its current rate of ~25% primary use to 50% primary use.[14]

However, several caveats need to be considered. First, we note that in other countries, the proportion of domestic LPG-related burns has increased with the large-scale adoption of LPG as a cooking fuel.[25 26] In those studies, the most common cause appears to be LPG leaks that lead to fires; users' knowledge of proper operation of LPG cooking systems also contributes to adverse outcomes.[26] This does not contradict our results; we find that LPG carries some risk, but that the proportion of burns is higher when biomass fuels are in use. Second, while our analysis focused on household-level risk factors, the risk of accidental explosions along the LPG distribution system, which often results in casualties with more than one victim, cannot be ignored. Though annual estimates of such events in Ghana are not available, episodic documentation from Ghana and other sub-Saharan countries indicate that they are not frequent but detrimental, nonetheless.[27 28]

Taken together, these results suggest that the planned expansion of LPG as a cooking fuel in Ghana has the potential to reduce the risk of cooking-related burns observed among solid fuel users, if and only if, it is met with extensive awareness raising and safety training around the proper use of LPG. This recommendation aligns with the finding that among respondents, those who had experience using LPG were less likely to perceive it as an unsafe cooking option (online supplemental table S4). Importantly, LPG adoption may not translate to exclusive LPG use, as illustrated by the stove stacking patterns observed in this study (online supplemental table S5). Finally, nearly all (99.7%) Ghanaian households (table 1) use either LPG, charcoal or wood as their primary cooking fuel, highlighting the fact that electricity is not commonly used for cooking despite Ghana's high electrification rate. While electricity may also provide a safe alternative to solid fuels, several factors likely contribute to its infrequent use for cooking including the high cost of electricity, the recurrent grid outages and the inadequate wiring for cooking loads in most homes.

In Ghana, the transition from a refill model to a recirculation model for LPG implies that empty LPG cylinders will be procured, branded, maintained and filled prior to distribution to consumers and households through retail outlets. On the one hand, the implications of this model are that (1) the responsibility of LPG cylinder maintenance will shift from the household to the LPG bottling plant and (2) LPG bottling plants will be sited away from congested commercial and highly populated areas, thus reducing the health impacts of potential production or distribution-related incidents. On the other hand, increased LPG access in communities that are not familiar with it has the

Table 4 Bivariate association between risk factors and cooking-related burns presented separately for adults and children, Ghana

		OR	95% CI
Adults	Cooking fuel		
	Wood	2.29	1.02 - 5.14
	Charcoal	2.40	1.04 - 5.55
	Cooking location		
	Outside	3.03	1.39 - 6.63
	Urbanicity		
	Urban	0.92	0.58 - 1.47
	Wealth index		
	Q1 (Wealthiest)	2.62	0.93 - 7.36
	Q2	4.24	1.60 - 11.28
	Q3	4.86	1.85 - 12.78
	Q4	1.40	0.44 - 4.43
	Household size		
	Each additional household member	1.0	0.91 - 1.1
Children	Cooking location		
	Outside	2.81	1.11 - 7.08
	Urbanicity		
	Urban	0.94	0.54 - 1.63
	Wealth index		
	Q1 (Wealthiest)	0.64	0.19 - 2.18
	Q2	2.22	0.88 - 5.59
	Q3	2.22	0.89 - 5.51
	Q4	1.61	0.61 - 4.26
	Household size		
	Each additional household member	1.20	1.10 - 1.32
	Household head demographics		
	Age	0.99	0.97 - 1.01
	Sex: Female	0.30	0.14 - 0.67
	Education: Post high school	1.02	0.48 - 2.20
	Education: Some university	1.31	0.40 - 4.26

The reference categories for urbanicity, wealth index and education are 'rural', 'Q5 (poorest)' and 'less than high school' respectively. 95% CI = 95% confidence interval.
Respondents (N=7389) were interviewed between February and March 2021 and were asked about burns that occurred in the previous 12 months.

potential to increase the risk of severe cooking-related burns. This reinforces the need for educational programming at the community level, especially in communities that have largely relied on solid fuels. The implementation of this policy may underpin a needed framework for safety legislation and operational standards in the industry.

In addition to cooking fuel type, we identified other household-level risk factors for severe cooking-related burns. In households with a larger number of people, children were at increased risk of cooking-related burns. This finding is supported by other studies that point to crowdedness as a risk factor for burns because it increases the risk of accidental injuries.[29] Further, in households where the household head was female, children had lower odds of experiencing such burns. Previous studies focusing on different child health outcomes found no clear relationship between the type of households and child health across countries but found significant relationships for specific countries,[30] highlighting the role that sociocultural contexts play in shaping those relationships. Finally, studies have documented an association between socioeconomic conditions and the incidence of burns finding that low-income status was a risk factor.[29 31] We found a non-monotonic association between wealth and incidence of burns, contradicting the findings of prior studies, but note that most prior studies have focused on children.[16 29] As described, the household-level risk factors that we have identified differed for adults versus children suggesting that prevention strategies should be designed for specific populations.

Overall, we estimated that more than 300 000 cases of severe cooking-related burns occur in Ghana each year. As has been documented in other contexts, the majority of these burns affected working-age females who tend to be the primary cooks.[32] Young females, who are often called on to help with chores, also experienced a higher burden of cooking-related burns compared with young males. Given that burns can have dire and lifelong physical and psychological consequences,[33] these findings support the notion that household energy interventions providing alternatives to solid fuel use can contribute to women's empowerment.[34] Indeed, in severe cases, burn survivors may develop burn wound contractures and other physical impairments that can limit function, leading to disabilities and reducing their chances of leading economically productive lives.[35 36] If they occur, these disfigurements often result in patients experiencing the effects of social stigmatisation and restriction in their participation in society.[33] While these consequences have been understudied in Ghana, a couple of descriptive studies have documented both the physical and psychological impacts of burns on patients. A study from the Komfo Anokye Teaching Hospital in Kumasi documented that one-third of burn survivors with a disability could no longer move their arms.[35] In a qualitative study at the Korle-Bu Teaching Hospital in Accra, some respondents reported that they felt stigmatised, were being described by their deformity or had been assigned new jobs because of their appearance.[37] In our study, physical toll seems to resolve over time with little permanent impairment (online supplemental table S6), but we did not ascertain impacts on psychological health.

Beyond the health and quality of life impediments associated with burns, the estimated burden of cooking-related burns in Ghana can have significant financial implications for the country's public health system. Most severe burns lead to prolonged and expensive hospital stays. A systematic global review estimates that the mean cost of treatment per patient is substantial and can go up to over US$125 000.[38] These elevated costs can in part be explained by the comprehensiveness of care required by burn patients: in addition to receiving pain management and wound care, burn patients benefit from attention to nutritional deficiencies, to the consequences of suppression of the immune system and to rehabilitation therapy.[39] Data on the average hospital charges for care of a patient with extensive burns in Ghana were not available. Global burn registry data among reporting hospitals from the WHO African Region suggests that hospital stays for burn patients in the region are longer, but that two-thirds of them result in patient discharge without impairment.[6] It is important to note that many burned individuals who should get timely care will not, and therefore, would not be accounted for in this registry. Though not all cooking-related burns will require intensive and extended treatment, taken together, this evidence suggests that a national registry of burns should be put in place to provide data that is currently absent. Such a registry along with future investigations of the prevalence and risk factors of severe burns in LMICs will provide much-needed data on the costs and disability implications of burn injuries, thus supporting the design and prioritisation of evidence-based recommendations.

This study presents both strengths and limitations. Our analysis relies on the largest (n=7389) national survey of energy use in Ghana. A major advantage compared with studies that only report primary cooking fuel is that we were able to ascertain

the fuel in use at the time severe cooking-related burns (our primary outcome) occurred. Another strength of the study is that it allowed us to capture burns incidence in community settings; though the demographics and profile of burns reported here differ from those that might be reported from hospitals,[40] we uncovered epidemiological evidence on burns for injured individuals who might not seek care. In terms of limitations, we note that our definition of burn severity does not align with the definition typically used in medicine. Typically, third-degree burns that cover more than 1% of the body are considered severe. However, we chose to use the burns module and definition developed by the Clean Cooking Alliance to allow for comparison across settings in future studies. Given the restriction to cooking-related burns, we did not further investigate the specific mechanism by which documented burns occurred, which could have had meaningful policy implications. Our findings rely on self-reported outcomes, which were not compared with responses from other members of the household. However, it is fair to assume that the respondents, who were the primary cooks, had a substantial role to play in caregiving, and therefore, might more accurately remember children's injuries than the children themselves. Recall bias might also have affected the findings. We used a recall period of 12 months given that the definition of the outcome ascertained included a substantial change in normal activity (thus minimising recall bias).

CONCLUSION

Leveraging a national survey, we documented the incidence of severe cooking-related burns in Ghana. We identified modifiable household-level risk factors and found that this under-characterised outcome disproportionately affects young and working-age females. Assuming expanded LPG adoption in Ghana includes safety training around the proper use of LPG, the promotion of LPG may lead to safer fuel use with the potential to reduce the incidence of severe cooking-related burns.

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Acknowledgements This work is undertaken as part of the Columbia World Project, Combating Household Air Pollution with Clean Energy, Columbia University in the City of New York (no grant number). Ghana Statistical Services provided support in planning and implementing the survey. AGL was supported by the National Heart, Lung and Blood Institute, grant K23 HL135349.

Contributors MD accepts full responsibility for the finished work, had access to the data, and controlled the decision to publish.

Funding The study was funded by Columbia World Projects (No grant number) and National Heart, Lung and Blood Institute (K23 HL135349).

Competing interests None declared

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and ethical approval for this study was obtained from the Institutional Ethic Committees at Kintampo Health Research Centre (KHRCIEC/2020-5), Ghana Health Service Ethics Review Board (GHS-ERC:003/03/20) and Columbia University Institutional Review Board (IRB-AAAS8293). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. Data will be shared on reasonable request.

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